HISTORIC STRUCTURES REPORT

PART I

ARCHITECTURAL DATA SECTION

ON

THE PAW PAW TUNNEL

C & O Canal National Monument

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for

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I. EXISTING CONDITIONS

The Paw Paw Tunnel, 3117 feet in length by actual measurement, runs north six degrees and thirty minutes east through a low ridge[1] paralleling Green Anthony and Sorrell Ridges to the west. Its downstream or north portal is 155.2 miles along the towpath above tidewater in Georgetown, D. C. It is less than two miles from Paw Paw, West Virginia, the nearest town from which it derives its name.

The tunnel and approaches were designed by Charles B. Fisk, Chief Engineer for the Canal Company, and its construction was started in June 1836 by Lee Montgomery, Contractor. Construction lapsed in 1842 and was resumed in 1847 for reasons detailed in the Historical Data Section. The tunnel was completed and in operation by 1850.

A longitudinal section through the tunnel is shown on a sketch included in the Appendix. The depth of the tunnel below ground varies due to the topography of the hill through which it passes. Its greatest depth is 360 feet and its lesser depths occur at the shafts.

The shafts were employed to increase the working surfaces and were bored in pairs, with one shaft presumably used for ventilation, while the other was used for hoisting men, tools and rock spoil. These paired shafts were located, a pair in each of two ravines, near the north portal. Their locations were selected to minimize the hoisting height and to provide suitable spoil area for the material removed from the bore. From the record it appears that they were eight feet in diameter, and a pair were spaced twenty-three feet apart.[2]

When construction was completed the shafts were capped in the manner shown on the sketch in the Appendix. Their location has been noted on the site as well as the spoil piles of excavated material.

Six stones (five of which have been recovered) were located in line and on the high points of the hill above the tunnel. They were undoubtedly set for the purpose of aligning the bore and checking the work as it progressed. They are about ten inches square on top and protrude from the ground a similar distance. They have a groove on the top face that runs perpendicular to the line of the tunnel for marking the distance, and a small hole is drilled in the groove for marking the alignment.

Little is known about the actual mechanics of opening up the bore, but references are made to the blasting out of large stones that were further reduced in size by sledge, with some of the material being loosened with picks.[3]

As the tunnel is lined with brick, it is not possible as of this date, to observe the tool marks on the rough bore. That the excavation was hard work and a real accomplishment for its day can be readily appreciated.

Narrow gauge track was laid for employing carts to dispose of the excavated material. Some of this spoil material was hauled considerable distances. That which can be seen is composed of fragmented shale.

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1 No name for this ridge has been found to date.

2 Luzader, John F., *Historic Structures Report, Part I, Historic Data Section, for Tunnel*, submitted February 1963, p. 13.

3 *Ibid*, p. 14.

The work was conducted in shifts, and as many as 250 men were employed at a given time. Welsh miners, Irish laborers and masons from England and the local scene were on the force.

The north and south portals are similar in design and were laid up with large, coursed, scabbled stone. The ringstones and keystone of the arch, the belt course and the capstones of the cornice are composed of cut and dressed stone. The face of the portals has a slight batter and buttresses, five feet wide, flanking the entrance openings. Stepped flanking walls retain the side embankments and provide access to the top of the portals.

The north portal has a swinging boom that was used to drop timbers into slots in the masonry at each side of the tunnel so that the canal bed downstream of the tunnel could be emptied for repairs. On the west side a platform with several raised stones was used for storing the timbers when they were not in use.

Above the keystone of the north portal a twenty-two inch high by twenty-six inch wide stone plaque is inscribed J. M. Coale, President, 1850. The keystone at the south portal is inscribed C. B. Fisk, Engineer. Whether either of these stones were hollowed out to receive memorabilia or token commemorating the construction of the tunnel is not known.

The interior of the tunnel is lined with cut and dressed stone extending from the face of the portals toward the interior, a distance of 26'-3" with every other course toothed back eighteen inches to bond with the brick lining of the balance of the bore.

The brick lining is composed of brick 9" x 4-1/2" x 2-1/4" with 9" dimension running parallel to the length of the tunnel and the 2-1/4" edge or face showing. Above the spring line of the barrel vault the brick are laid running bond fashion, while the brick of the side walls below the spring line are laid with alternate courses of headers. The finished interior width of the tunnel is twenty-four feet and the arch of the vault has a radius of twelve feet. Weep holes are provided at the spring line, at intervals. The lining was noted in one of the weep holes to be seven brick widths thick. It is possible that the thickness varies. The records mention a dry packing between the brick lining and the rough bore of the tunnel. While it cannot be observed at this time, it is conceivable that spaced pilasters or longitudinal ribs of brick were incorporated in the brickwork behind the lining to cut down the unbraced length of the lining, and to localize the effect of any settlement or fracturing that might occur in the rough bore.

The lining served a number of purposes including the elimination of rough surfaces that could hamper the passage of the boats, the diversion of seepage water so that cargoes would not be contaminated, and it provided an even surface for the reflection of any lights used by boatmen in working their way through. In addition, it prevented vermin and small wild life from infesting the interior. When the brick lining was applied is not known, but with the centering requires for its installation it must have been installed before traffic was permitted to use the structure.

The towpath runs along the east side of the tunnel and is five feet wide. Its floor is approximately thirty inches below the spring line of the vault. A guard rail at the edge of the towpath is made up of a 4" x 4" wood top rail set on forked wrought-iron posts, 2" square, spaced five feet apart. Two 2'1/4" x 4-1/4" boards, back to back, form an intermediate rail and are notched around the uprights. The posts are seated in the ends of cross timbers below the deck and are secured in place with iron straps. The railing extends outside the tunnel some twenty-five to thirty feet at each end. An interesting interpretive feature is the tow rope chafe marks on the top rail.

Rub rail timbers were bolted near the water line and ran continuously on both sides of the boat way and protected the boats as they passed through, as well as saving the brick lining from being damaged.

Seepage has damaged the brick lining in a number of places and it does not appear to pinpoint the source of the water. Some of it might be surface drainage finding its way down through seams in the rock above, or it might emanate from subterranean springs. This water seepage causes the most damage when it freezes in the wintertime. Its effects are most noticeable in the vault areas directly below the shafts. However, it is not confined to these areas and damage has occurred in many other points along the tunnel's length. The outer brick widths of the lining have become loose in large sections in several places, and that this is a recurring condition can be seen by the number of patches that have been made over the years.

To the north of the tunnel the canal traverses a hollow called "Anthonys" and sometimes corrupted to "Athys" in the canal records. This approach to the north entrance of the tunnel had to be excavated down to the working level of the canal bed, and was generally referred to as the "deep cut". A similar but smaller operation was required at the south entrance.

In the "deep cut" the underlying rock strata runs on an inclined plane on the east side of the cut and is composed of laminations about twelve inches thick. In excavating, the natural inclination of the rock was followed exposing large smooth inclined surfaces of rock. From time to time large sections of the laminations loosened making it necessary to drive steel pins through the laminations to hold them from sliding off onto the towpath and into the canal. The cut bears northeasterly from the north portal and the towpath hugs the toe of the inclined embankment.

Originally the towpath was constructed of wood timbers for a distance of about 1285 feet to a spring in the eastern embankment. Timber construction was used for the towpath, as solid material would tend to slough off the inclined surface. After the canal ceased operation the timber towpath deteriorated. It was replaced by the Service with shale except for 200 feet which was reconstructed like the original. Where shale was used it jutted out into the canal bed which narrows down the boat way.

The canal bed is silted up and several large boulders have fallen into the bed from the west embankment.

II. WORK REQUIRED AND FURTHER RESEARCH NEEDED

To stabilize the tunnel and approaches and restore them to a safe condition suitable for interpretation, a number of repairs should be instituted.

Of first importance is the correction of the condition that permits water to seep through the brick vault lining of the tunnel's interior. The source of this water has not been determined, but its concentration at the shaft locations it is possible that surface water above the tunnel may be seeping in through the shaft caps or down through rock seams that are intercepted by the shafts. Another possibility might be that an underground spring is the source of the trouble. An investigation of the interiors of the shafts could be made by removing their caps, and either lowering a man or a television camera into the shafts to find the points where water could be entering.

Not all of the seepage is found at the shafts, however, as other locations along the vault are damp and stained. It may be that the dry packing, between the brick lining and the bore through the rock, may be silted up to prevent the water from escaping solely by means of the weep holes that were left periodically along the spring line of the vaulted ceiling.

At the shaft locations it might be more practical to assume that the source of water cannot be diverted and that it should be collected and discharged into the canal bed by controlled means at the base of the shafts.

This may mean removing the brick lining and the dry packing under the shafts and replacing the dry packing with a vaulted concrete slab having curbs along its outside edges. The water caught by the slab would then be channeled to adequate weep holes from which it would spill into the canal bed. Once this was done the brick lining would be replaced.

At other locations of seepage it may be possible to cleanse the dry packing by hose stream played back through the weep holes. If this would not work, it would then be necessary to remove the lining and replace the dry packing with clean material. Once this was done the brick lining would be relaid.

The canal bed within the tunnel should be drained and cleared of all silt and debris making it possible to work on the brick retaining wall of the towpath. Much of this brick is in bad condition and sections of it have fallen out. Where the brick is bad or has fallen out, it should be replaced.

The wood rub or boat rails should be checked for soundness and where portions are missing or unsound, they should be replaced.

The steel posts of the towpath guard rail (625 in all) are mainly in good condition. There is one post missing, 838 feet in from the south portal, and a few of the posts in the vicinity of the shafts are heavily corroded. These should be replaced and the remaining posts cleaned of rust and painted. The steel straps securing the posts to the cross timbers should be removed, cleaned, painted and refastened. Where they are too corroded, they should be replaced for safety reasons.

The cross timbers are buried beneath the gravel towpath surface. These timbers should be uncovered and checked for soundness. They were probably creosoted or tarred, as facilities of this nature were available at the Canal Company's carpenter shop located at nearby Lock #66, only a half mile north of the north portal of the tunnel.

As much of the 4" x 4" top rail as possible should be saved to retain the chafe marks of the tow ropes. The intermediate railing will require some refurbishing and replacement.

It is not felt that the wood members used inside the tunnel require paint. Evidence has not been noted that would indicate they had ever been painted. It is certain and paint applied would flake off under the pressure of the entrapped moisture within the members.

The interior of the tunnel, once it is repaired and rewatered, will provide many interesting features for interpretation. Lights spaced periodically would provide a means for calling attention to pertinent features relative to the tunnel's construction and the problems that were overcome. It is suggested that the rub or boat rail, along the west side and visible from the towpath, be marked occasionally with the distances in from the entrances. Attention should be called to the comparative apparent sizes of the entrance openings as one travels through the structure, and how they appear to be equal in size when one reaches the midpoint between the two portals. The lighting should be of low intensity, placed low, with reflectors to cast minimal light on the towpath surface, with a proper intensity directed over the water surface onto the opposite wall. The lighting would provide a reassuring sensation as the visitor travels deeper into the tunnel. It would also make rescue operations easier in the event anyone went over or through the guard rail. The latter possibility is more likely with small children prone to climbing the railing or rough housing one another.

Spot lights would highlight the prominent features. Fixtures should be water and damp proof, and would be served by waterproof cable run on top of or below the east side wood rub or boat rail.

The present gravel towpath surface should be treated to avoid having loose stones kicked up into ones shoes and to eliminate the possibility of its being thrown into the water for the enjoyment of hearing it splash. Visitors have also been observed tossing handfuls at others for the scare effect.

Stones of both masonry portals that have been forced out of alignment should be reset and missing capstones should be replaced. The grade at the top of the portals between the face of the portals and the embankment behind them is level with the capstones of the cornices. At present drainage from the embankment works it way behind the masonry, and from frost action tends to move the capstones out of line. This water should be collected in drain pipes and disposed of off to one side. The top layers of stone masonry of the stepped flanking walls need resetting, and if possible, a sloping drain channel along the side next to the embankment should be worked in to carry the runoff away. The stone joints of the portal masonry should be repointed.

At the south end of the tunnel the brick retaining wall of the tunnel towpath extends a distance of 152 feet. This should be repaired as needed and the brickwork repointed.

The timber supported towpath through the "deep cut" north of the tunnel will have to be reconstructed. It would stop at a point 1285 feet north of the north portal. Two hundred lineal feet within this distance has been previously reconstructed by the National Capital Parks, and the 25 feet immediately adjacent to the tunnel is of masonry construction, leaving approximately 1065 feet of towpath to be rebuilt.

A sketch in the Appendix illustrates the construction of the towpath which requires reconstruction. The decking consists of two inch planks running normal to the direction of the path. The planks are butt jointed along their length and coped as the meet the slope and protrusions of the embankment along its east side. Because of the irregular horizontal profile of the embankment,

the width of the towpath varies, averaging around seven feet. It should be so constructed that at its narrowest point it is five feet wide.

The planking is supported by longitudinal timbers 6" x 6" in size and spaced about thirty inches apart. These in turn are carried on cross timbers 8" x 8" in size and spaced ten feet on centers along the length of the towpath.

The west end of the cross timbers have an 8" x 8" vertical post for support and their eastern ends are supported on 4" x 8" timbers laid at a slant conforming to the slope of the rock embankment. The posts are cross braced apart with 2" x 10" planks. A six inch square wood guard rail is supported thirty inches above the deck with six inch square posts located at the ends of the 8" x 8" transverse timbers. The guard rail is half lapped over its supporting posts. All of the timber construction, except for the railing, the railing posts and the walking surface of the deck should be creosoted.

The present towpath fill will have to be removed to provide space for the timber reconstruction. From what can be seen, a shallow bench of natural material was originally left as a base upon which the timber work could be set. What its condition is will have to be examined when the fill is removed.

While the construction is sturdy enough to sustain a motorized vehicle, the towpath through the tunnel is not wide enough even for a "jeep". As there is no space at the north portal wide enough to turn around, there appears no need for adjusting the width of this section of the towpath to accommodate vehicles. Adequate vehicular access up to the tunnel is available at the south end.

The mouth of the spring at the northern terminus of the wood towpath should be rehabilitated and provisions made to adequately conduct its flow under the towpath to avoid flooding the surface of the deck. A flight of wooden steps gave access to the spring from the towpath platform below. The photograph in the Appendix shows the direction of the stairs, with twelve risers leading up to the platform at the head of the flight. The platform was supported from below by a slanting timber. The steps were at least two inches thick with open risers, and were supported on three carriages. A single rail served as a guard.

Wells have been drilled near the tunnel making safe drinking water available to the visitor. As a consequence, it would appear advisable to omit reconstructing the wood stairs to the spring so visitors would not be tempted to try the water from the spring.

While the overburden on the towpath bench is being removed, the operation should be extended to clean the canal bed of debris and silt. The large boulders now lying in the bed would have to be blasted into smaller pieces for removal.

One of the centering stones on top of the hill above the tunnel has been somewhat shifted by vandals in an apparent effort to remove it. The stone should be realigned and firmly reset.

ILLUSTRATION NO 1
PHOTOGRAPH OF NORTH PORTAL

The portals are constructed similarly and are of equal size. They are twenty-four feet wide. The boom seen at the rebate of the pilaster on the right was used to slip timber gate sections into slots located in the masonry below the towpath level on each side and 2' - 2" forward of the face of the portal. The gates when not in use were stored on the platform on the right on the raised stones as shown in the photograph.

As can be seen, the stepped flanking walls at each side require attention. The top of stepped stones are loose and should be reset. The inscription stone above the keystone can barely be made out and is inscribed J. M. Coale, President, 1850. The keystone of the south portal is inscribed C. B. Fisk, Engineer.

The masonry joints of both portals should be repointed as well as the twenty-six feet long stone masonry returns of the vault and sidewalls within the tunnel.

NPS photo.

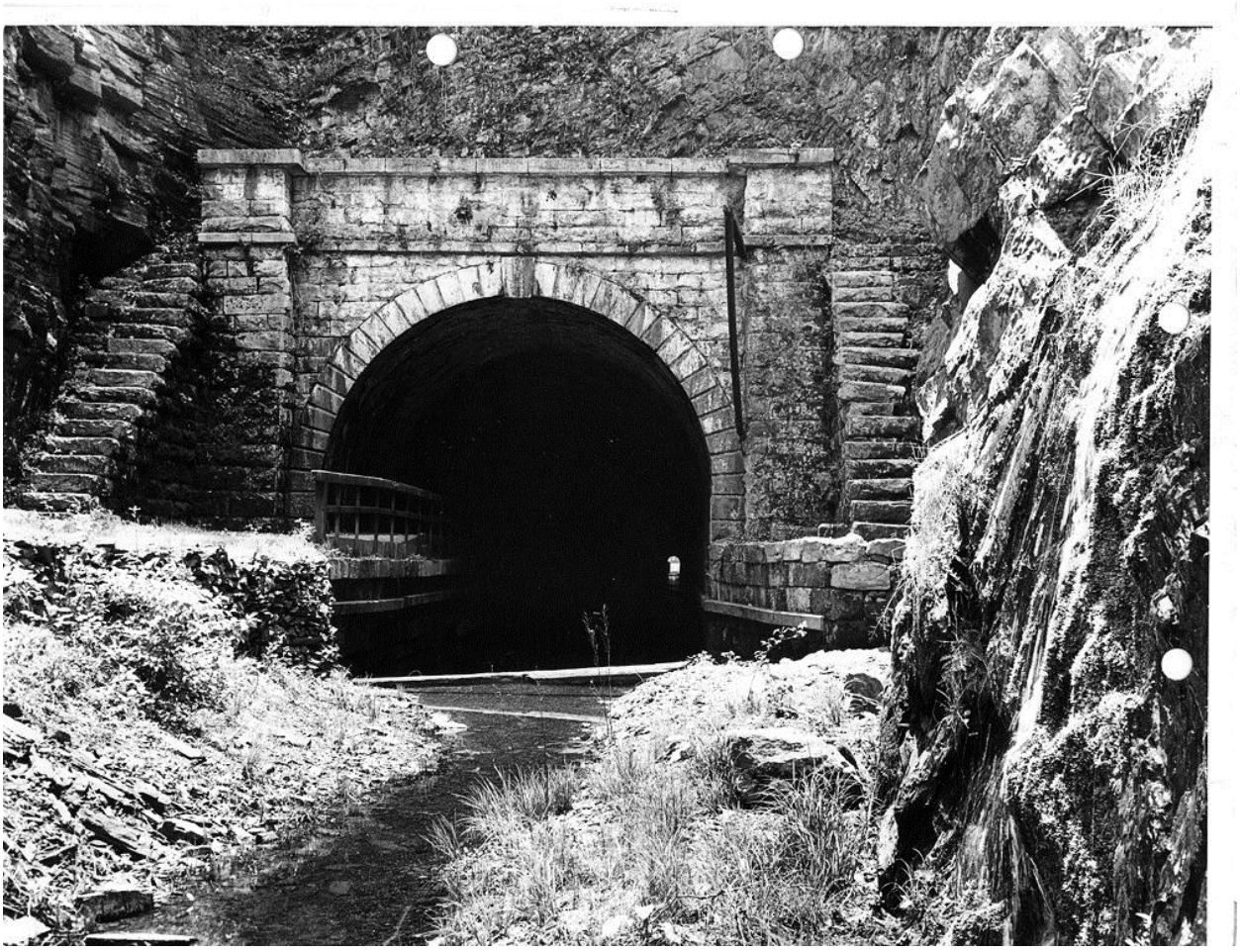


ILLUSTRATION NO 2
VIEW OF SPRING NORTH OF TUNNEL

The spring is located at the head of the steps. While it has been called a spring, it is not known for sure if it has a subterranean origin or if it is runoff water finding its way to this point from the ravine above. The effect of the water if it is not collected and channeled can be seen in this view, taken around 1910 as indicated by the style of the clothes worn by the people in the foreground. The stairs shown have probably been rebuilt many times over the years.

NPS photo.

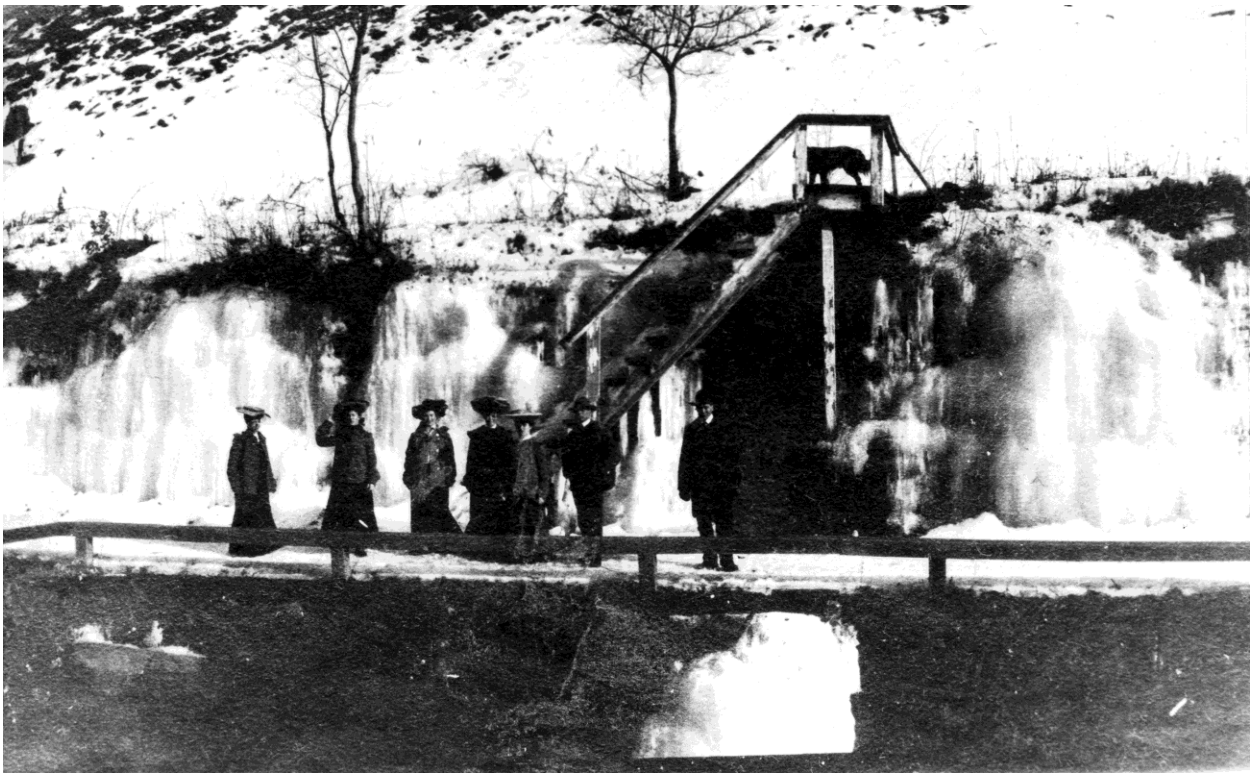


ILLUSTRATION NO 3
STONE ALIGNMENT MARKERS

There were six of these stones, five of which have been found and are located at high points of the ridge above the tunnel. They fall on a line above the bore of the tunnel. They were used to check the alignment of the work as it progressed and to determine the amount of work accomplished so that pay estimates could be made up.

The stone markers are approximately ten inches square on top, increasing to about fourteen inches at their base, and are around four feet long. About six to ten inches of their height is exposed above the ground. Each has a groove on top running perpendicular to the line of the tunnel and in the groove a small hole is drilled, probably to mark the center line of the bore. They do not appear to be local stone as they are reddish and have a quartz like texture.

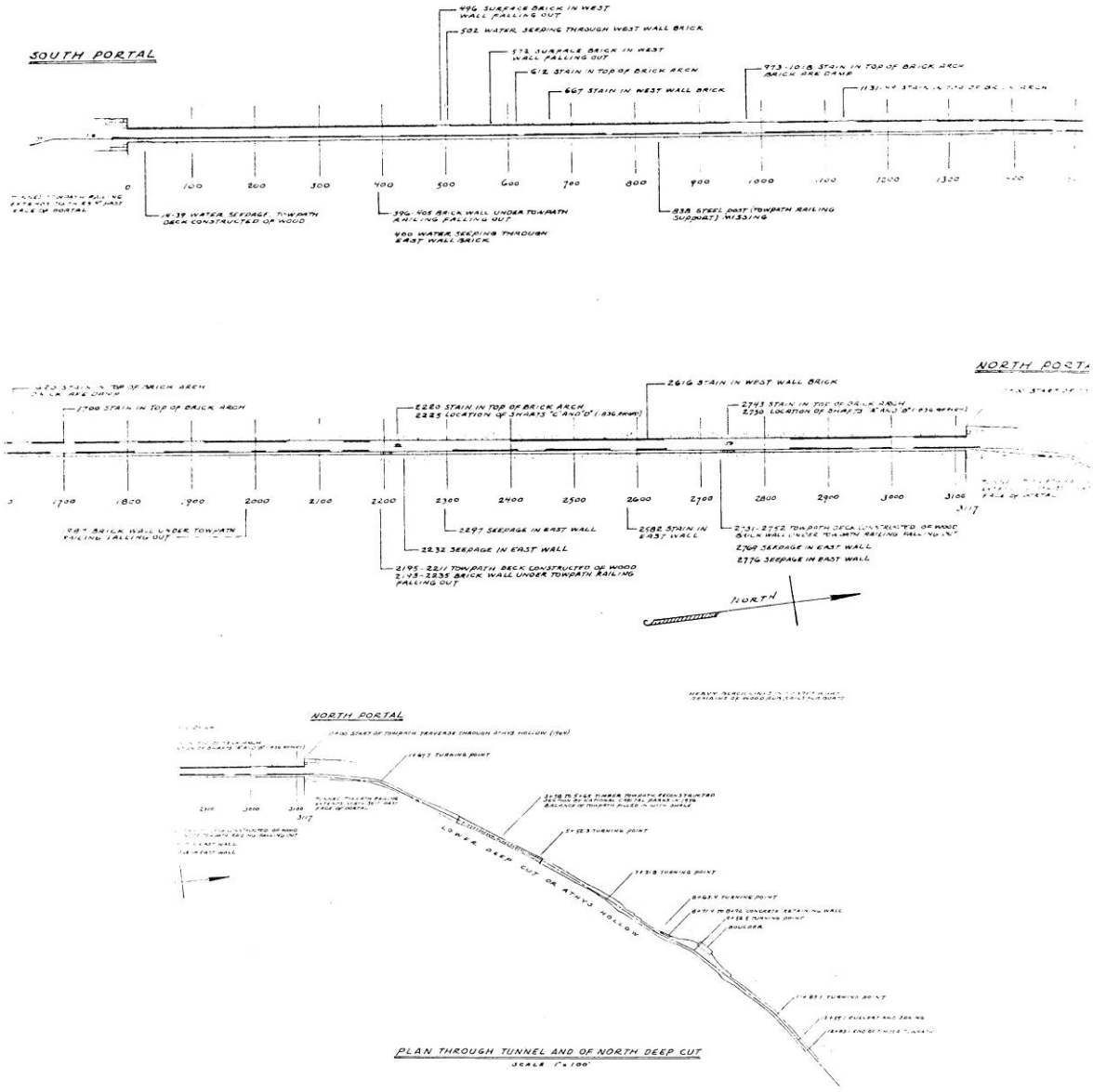
NPS photo.

SKETCH NO. 1

PLAN OF TUNNEL AND NORTH DEEP CUT

This plan shows the data collected with the aid of summer student assistants. The heavy black lines within the tunnel show how much of the rub or boat rails remain at present. Various notes call attention to the more noticeable areas where water or dampness is permeating the brick vault lining. The distances given were measured at the site.

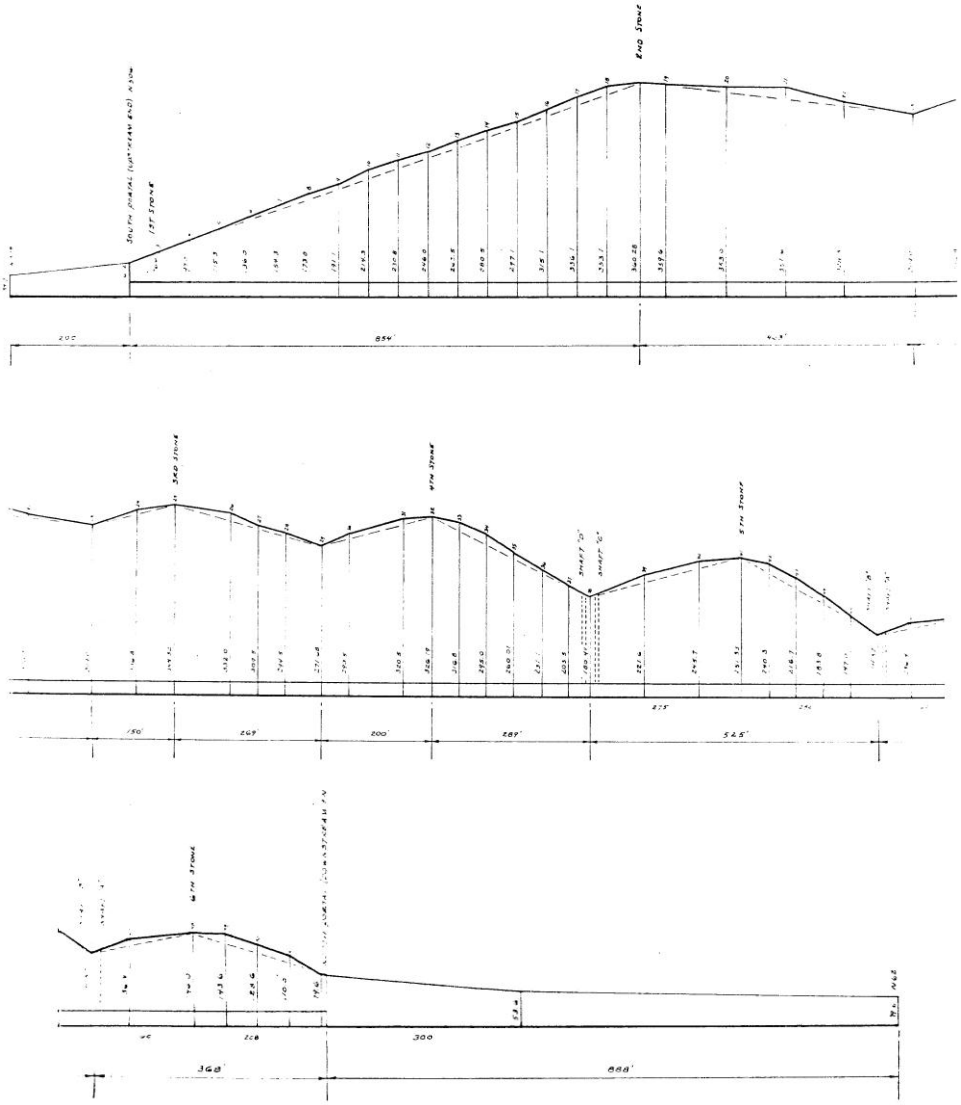
A traverse through the "deep cut" and beyond is delineated and shows the amount of timber tow-path reconstructed by National Capital Parks. The spring mentioned in the report is shown as well as the point where a massive boulder has fallen into the canal bed.



SKETCH NO 2
PROFILE THROUGH TUNNEL AND APPROACH CUTS

This drawing is adapted from a Canal Company drawing dated December 1, 1836. The shafts are noted in the two northernmost ravines. The alignment stones were located on the ridges over the bore and their locations from the ends of the tunnel are given. The stone labeled "third stone" has been shifted and should be reset correctly. The stone labeled "first stone" has not been recovered. It may have stolen.

Sketch by Archie Franzen

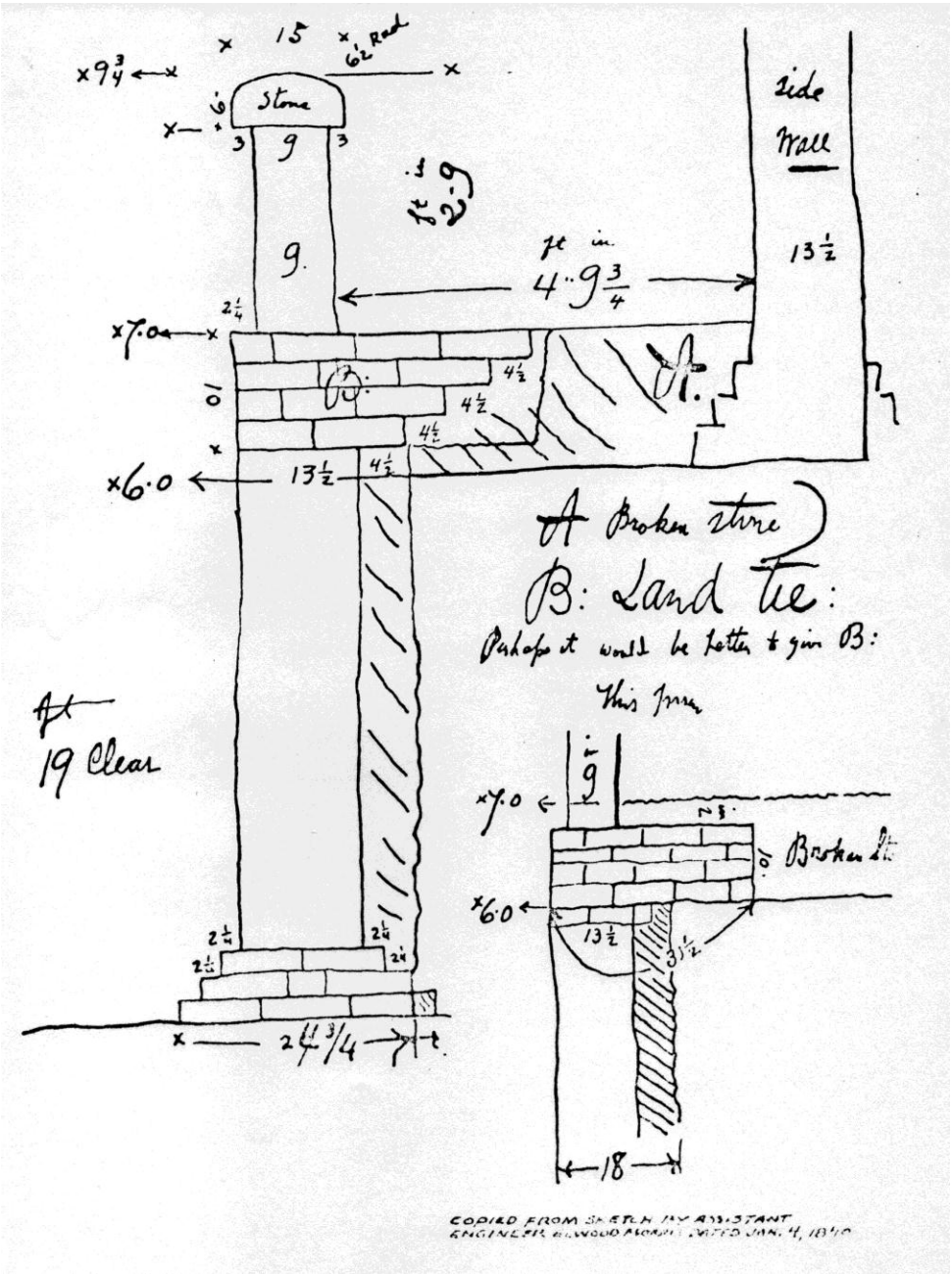


TUNNEL AT PAW PAW BENDS
LONGITUDINAL PROFILE
ADAPTED FROM DRAWING PREPARED DEC. 1, 1836 UNDER THE DIRECTION OF ELLWOOD MORRIS, ASST ENGINEER.
SCALE 1" = 100'-0"

SKETCH NO 3
COPY OF EARLY PROPOSAL FOR CONSTRUCTING
THE TOWPATH WITHIN THE TUNNEL

This sectional sketch would indicate that a shelf was left in the bore for the tunnel towpath. However, this has not been ascertained. The brick and stone railing was not built. Instead a wood railing supported on wrought-iron posts secured to wooden cross members was used. This is more fortunate in that a brick parapet type wall of only nine inches in thickness could scarcely have withstood the combination of moisture within the tunnel and the strain of the tow ropes.

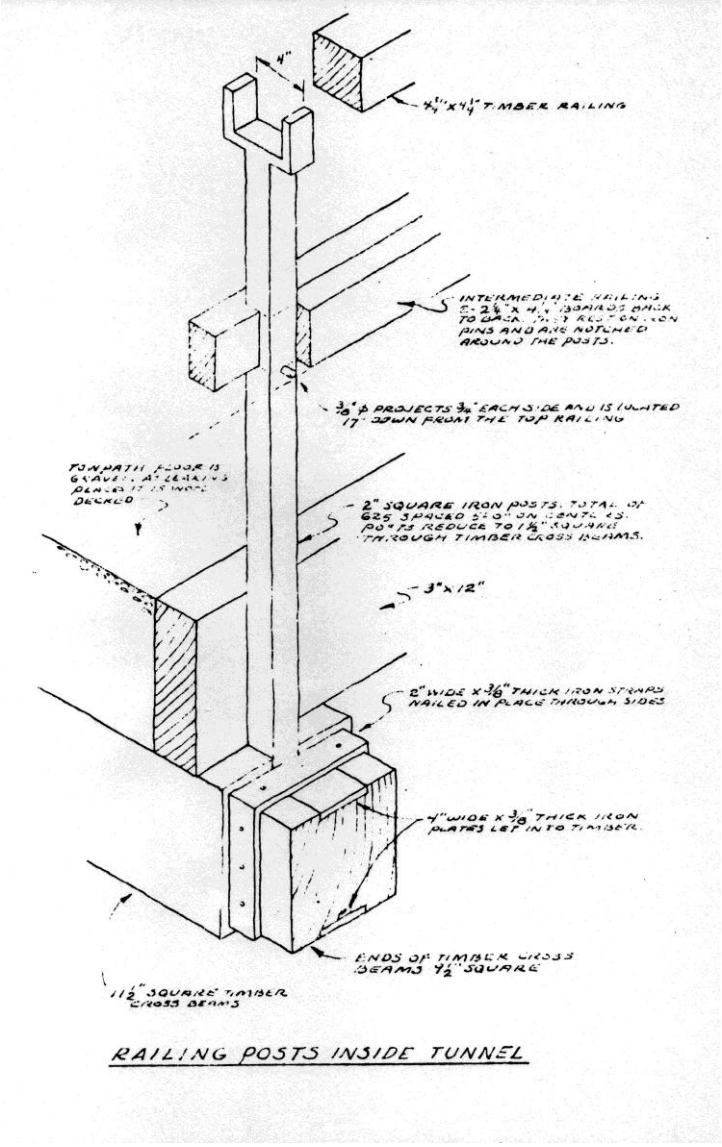
Copy by Archie Franzen



SKETCH NO 4
DETAIL OF TOWPATH RAILING WITHIN THE TUNNEL

The railing now in use is pictured in this sketch. The uprights are two inch square iron posts wrought to form a fork at the top to receive the four inch square wood railing. An intermediate railing was made of two pieces and notched around the posts. They were kept from sliding down the posts by 3/8" round pins driven through the posts so that the bottom of the rail rested on the pin.

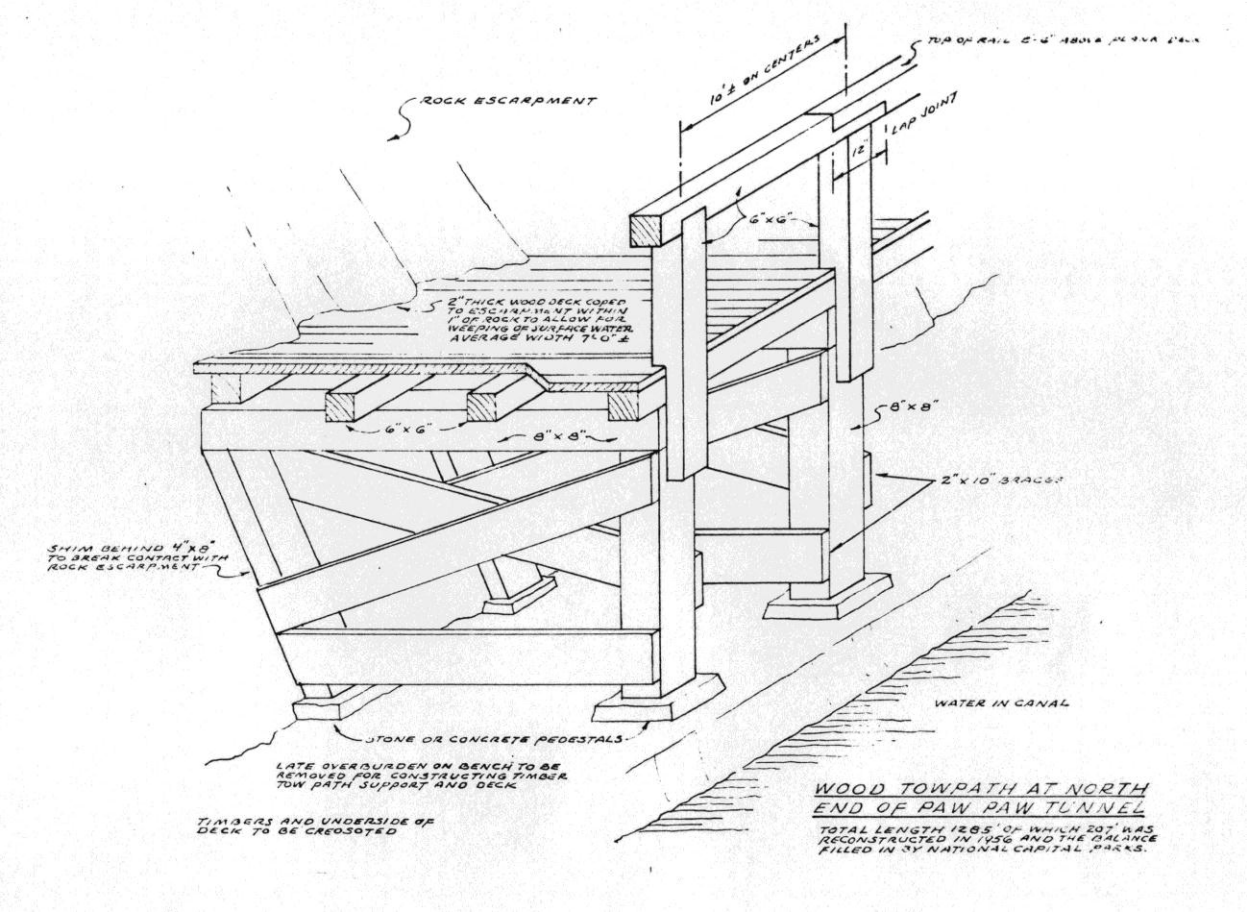
The posts were secured to eleven and a half inch square cross timbers reduced to nine and a half inches square at their ends. The portion of the iron posts passing through the timber was reduced to one and a half inches square and also passed through 4" x 3/8" iron plates which were let into the top and bottom faces of the timber. The plates acted somewhat like washers and the whole assembly was further secured in place by 2" x 3/8" iron straps nailed to the timber.



SKETCH NO 5
TOWPATH CONSTRUCTION NORTH OF TUNNEL

The railing outside of the tunnel is lower than the railing within. Timber construction was more likely adopted because of the sloping embankment and the difficulty of establishing a uniform bearing for a retaining wall that would have been necessary to hold solid material in place. The canal bed is relatively narrow within the "deep cut", and as a result space was at a premium. This type construction also permits surface water from the steep and laminated embankment to drain under the towpath and into the canal.

Sketch by Archie Franzen



SKETCH NO 6
SKETCH INDICATING METHOD OF CAPPING
THE TUNNEL SHAFTS

Filling the shafts with loose material would have imposed a very considerable load on the tunnel's brick lining. This probably explains why the shafts were left open and capped following the completion of construction. The conical brick caps were founded on natural rock and brought up to final grade and to a diameter convenient for bridging with a cover. The stone covers were made in halves because of their weight, allowing them to be placed or removed as necessary. The backfill around the brick was puddled to form an impervious protection and the whole covered with stone termed "dry packing" in the Canal Company records.

Sketch by Archie Franzen